ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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WD-DWGB-1-4 2007

Dug Well Design

For the most part, this document assumes the reader will be installing a new well. See comments near the end for suggestions concerning inspection of existing dug wells. For springs see fact sheet WD-DWGB-1-6 Point Well Design. For well abandonment, see the fact sheet WD-DWGB-1-7 Well Abandonment and Decommissioning.

Government Regulations

State Regulations: A person or firm in the well construction business must be licensed by the NH Water Well Board of DES. A homeowner can install their own well without a license. The Well Board requires the submission of a "well completion report" describing well's design, construction, the soil and rock conditions encountered, and the well's yield.

There are **statewide** design criteria rules for dug well **construction** and **placement**. These rules were revised in 2000. The rules are numbered We 100-1000. There are no state requirements concerning minimum well **quality** or **quantity**.

Finally RSA 477:4-c requires, when selling a home with an on-site water system, disclosure of the water system's location, malfunctions, date of installation, date of the most recent water test, and whether or not the seller has experienced a problem such as an unsatisfactory water test.

Local Regulations: Some towns may have local permit requirements relative to the placement, construction, water quantity or quality for private wells. Please contact your local health officer or code enforcement officer for particulars.

Evaluating a New Water System

Determining How Much Water You Use

To determine needed well yield, you must first estimate your water demand. A typical household requires approximately 5 gallons per minute (gpm) to meet modest domestic water needs. However, as little as 2-3 gpm could be tolerated where storage is available. Factors to be considered when determining a family's minimum demand on a water system include: the number of water uses, their flow rates, how many of these uses could occur simultaneously, and for what duration. Landscape watering is the most extreme water use flow for most residences.

Determining How Much Well Yield You Need

What minimum well yield will satisfy a family's water needs is more difficult to identify. A low yield well (1-3 gpm) may be acceptable if one makes use of water stored in the well hole or in large basement storage tank(s). The storage in the well is not available if the water table drops below the pump suction in the summer and fall. Such storage in the well may allow installation

of a higher capacity pump if the duration of pumping will be short. In such cases, a low water cut-off device should be installed to prevent damage to the pump. The typical 3.0 foot diameter well casing has a storage volume of approximately 50 gallons per foot of water depth. Large non-pressurized storage tank(s) installed in a basement can serve this same function of accumulating water during periods of non-use. However, an additional pump will be necessary to pressurize this stored water. See fact sheet WD-DWGB-1-13 Determining the Yield of a Residential Well concerning the safe yield of wells.

DES has published a document entitled "Well Yield, How Much Water is Enough?," which is available for $2 through the Water Well Board. The US Department of Agriculture, Farmers Home Administration Guidelines requires a minimum well yield of 1,200 gallons for a four-hour period. For more information on minimum well yield please see fact sheet WD-DWGB-1-8 Recommended Minimum Water Supply Capacity for Private Wells.

It should also be noted that a well's yield may change with time. This change can be a seasonal variation or long-term trend. Thus, one should try to develop the maximum well depth within economic reason when the well is first installed. It is not uncommon to have at least a 5-10 foot variation between early spring and late fall groundwater levels. This variation can be significant in wells of limited depth.

Dug wells are more susceptible to drought. This condition can be minimized by excavating the bottom of the well significantly below the seasonal low water table. The seasonal high water table can be determined by soil experts based on color change of the soil. It is difficult to determine the seasonal low water table. Consequently the depth of a dug well is normally governed by the capability of the construction equipment, or the level at which you encounter bedrock or till. The best time to construct a dug well is in the early fall when low water tables allow the deepest well construction. This will minimize muddy conditions and excavation cave-in.

Water Quality Considerations
Dug wells experience iron, manganese, and taste and odor conditions approximately as often as bedrock wells. Dug wells generally do not experience arsenic, fluoride and radiological problems that are seen in bedrock wells. Dug wells often experience bacterial problems caused by poor design and construction materials.

Well Protection and Placement
Since dug wells take water from the highest water table, they are extremely sensitive to those activities that take place in the immediate vicinity of the well.

Examples of chemical hazards to a well include the application or inadvertent spillage of fertilizer, pesticides, and inappropriate disposal of old crankcase oil, anti-freeze or solvents, or waste salt brine from water softeners. Thus, the use of chemicals in your backyard, or that of your uphill neighbors, may negatively affect the quality of the water table from which your well draws.

Laboratory tests for these chemicals can be costly. The best and least costly approach to protect water quality is prevention of pollution rather than treatment after the fact. Be careful with respect to the use and disposal of chemicals near and upstream of your well.

The following protective distances are required or recommended when locating a well for a private single family home:

a) Surface water and drainage culverts should not pass within 25 feet of a well; 50+ feet is recommended.
b) Animals should not be penned or tied within a minimum of 20 feet of a well; 75+ feet is recommended.
c) Leach fields and septic tanks shall not be located within 75 feet of a well.
d) Wells should not be located within 50 feet of the right-of-way line of roads, preferably more.
e) Wells shall not be placed within 75 feet of adjacent property which you do not control. (See RSA 485-A:30-b). If placement is made necessary within 75 feet, a "standard release form" is required to be signed by the well owner and given to DES, the town health officer and the registry of deeds. Since most zoning codes require a 10 foot setback, this distance is effectively 65 feet.
f) A well should not be placed in locations subject to ANY flooding unless the immediate vicinity (25' radius) of the well is built up above the maximum flood level.

Choosing The Well Type You Will Purchase
Based on the considerations above, such as soil depth, water needs, and existing pollution, a well type can now be chosen. In many cases there is relatively little choice since the choice of well types is largely influenced by the type of soil and the water availability on the property.

Contracting With a Dug Well Contractor
Prior to actual excavation, you will need to provide the contractor with guidance as to what concept will govern the amount of work to be done. Normally, dug wells are installed on a lump sum contract basis. However, this method does not ensure the deepest well unless that issue is specified as part of the agreement. The requirements of the contract are strictly between the homeowner and the well contractor.

Construction of New Dug Wells
Excavation and Backfill
When beginning excavation, place different soil types in different piles so that they may be replaced in the same sequences as removed. Upper soil layers may be high in bacteria, organics and readily soluble iron and manganese. If these poor quality soils are placed below the water table during backfilling, water quality problems may occur.

The well should be as deep as possible to prevent its going dry during droughts. Excavate in the fall. Try to prevent an accumulation of fine silt in the bottom of the excavation. An accumulation of silt may form an impervious layer reducing the entry of water into the completed well. Before placing the crushed stone and casings, break-up this fine sediment layer. At least 10 feet of soil should cover the highest level of crushed stone. During backfill, place the soil in 1 foot lifts and compact to prevent future settlement. Settlement creates open pathways in the soil that will allow the entry of bacteria into the finished well.

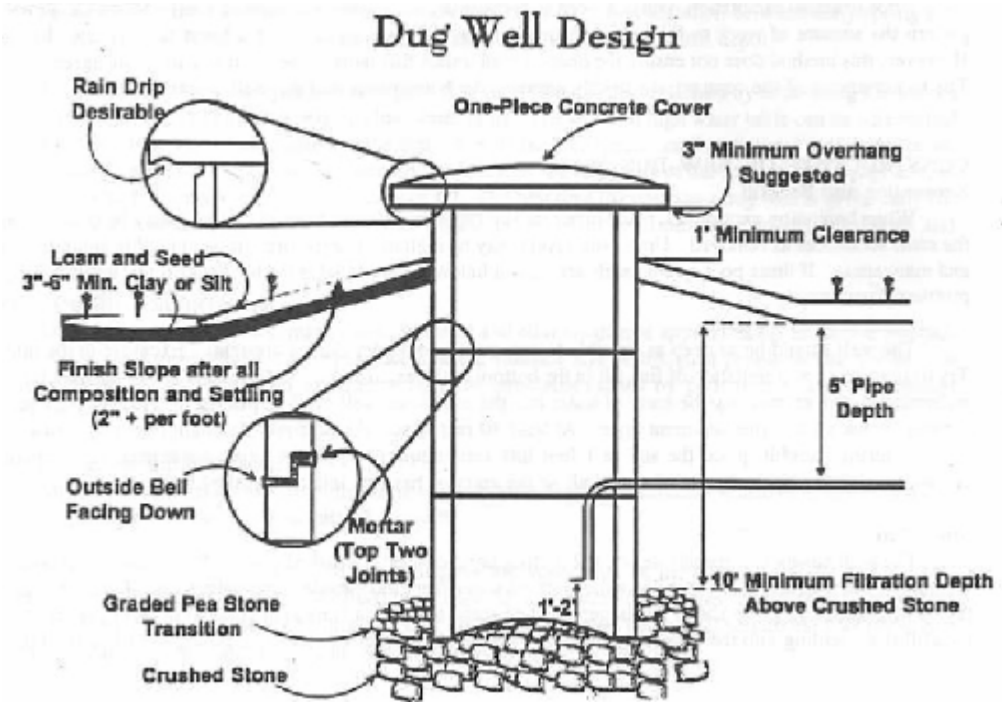
Stone Bed
The well casing is normally set on a 2+-foot layer of 1-2+ feet crushed stone. This allows convenient leveling of the well tile, and also allows the entry of water from the outside surrounding soil. Place multiple layers of graded pea stone above the larger crushed stone to act as a transition zone. This will prevent the backfill from settling into the crushed stone in the future. DES does not recommend the use of straw, tar paper and other degradable materials on top of the crush stone, as they may potentially cause bacteria and taste problems, and will likely also disintegrate with time.

Pipe or Concrete Tile Sections
Pipe sections should be joined by bell and spigot, or tongue and groove connection

configuration. This is critical since frost heaves or pressure from uphill soil will often displace tiles that are not locked into one another. Once the joints are sufficiently offset, soil will fall into the well. This in turn will cause settlement of the backfill that will allow unfiltered surface water, with bacteria, to migrate into the well. Such soil material will also damage the well pump. Joints should be oriented as shown in the diagram (outside tongue facing down). The joints between the highest two well casings should be cement mortared to achieve a water tight condition. Another sealing alternative is the use of a safe manmade sealant.

Water should enter the well at the bottom, either horizontally or up through the bottom. This will ensure maximum filtration of water through the soil. The lowest concrete casing may have perforations in its side wall. Wire reinforced concrete is suggested for well casing rings and the top cover.

Top of Page



Apron

To insure filtration of all water entering the well, an impervious apron of clay or fine silt should be placed entirely around the well. This apron should be approximately 5-10 feet wide or as wide as the excavation that was made to install the well. The apron slope should be approximately 2+ inches per foot. A greater slope should be considered if substantial settlement of the backfill is expected. Finally, the apron should be loamed and seeded to achieve a stable condition. Without sloped backfill, puddles of contaminated water will form in contact with the well casing and potentially leak into the well. This condition often results in bacterial contamination.

Cover

A center observation hole is NOT recommended. If one exists within an existing well cover, it should be sealed tightly to prevent the leakage of contamination into the well from above. If the observation hole is subsequently opened, the seal must be remade.

The cover should overhang the well and have raindrip on the underside to prevent the leakage of contamination into the well. The cover shape shown in the diagram is not regularly available in New Hampshire; however, we are requesting that concrete precasters adopt this shape in order to

solve the underside leakage potential. The underside of the well cover may not be totally flat. It is suggested that reference marks be placed on the cover and casing to ensure the same alignment each time the cover is replaced. Mortar or sealants can then be placed on the vertical sidewall to match irregularities on the under side of the cover. As an alternative, high points in the casing can be marked and ground down by an abrasive wheel or circular saw. DES suggests the cover overhang the casing by at least 3 inches. This may help keep the soils next to the well casing dry, which in turn may reduce the incidents of frost heaving of the top casing.

Another option to allow an observation port in the cover would be to fabricate a second light weight, easily removable cover to fit over the entire concrete cover. This second cover would act as a rain shield. This shield should be lockable to prevent vandalism and could be made from welded steel, aluminum or sheet metal. The locking attachment can be on the side edge of the concrete cover. Plastic sheeting is not stable and is not recommended.

Water Supply Line and Pump
Provide at least one foot of clearance between the suction end of the pipe and the bottom of the well. Provide a minimum of 5 feet of cover over the water line to the home for frost protection. Before backfill, first take field measurements, and then draw an accurate sketch of the precise route of the water line from the well to your home. Duplicate this sketch, laminate, and attach one copy to your pressure tank or fuse box. In the basement, seal the inside of the electrical conduit and water pipe to reduce that radon gas entry route into the home. A centrifugal pump is most often used in dug wells. Jet pumps allow easy repair, but are not energy efficient.

After Construction Activities
Determining the Well's Safe Yield
You should know the well's safe yield. Once the dug well is installed, a pump test can be performed. The safe yield of a newly completed well can be determined (and the well can be flushed) by high volume pumping water continuously over a sustained period of 24 or more hours. The pumping rate should be measured by noting the number of minutes required to fill a known volume container (such as a 20/32 gallon trash can). The water level in the well should be measured as the pumping continues. Measuring the drawdown is the most difficult portion of a pump test.

The intent of the pump test is to develop an equilibrium between the amount of water being pumped out of the well and the amount which is replenished naturally from the ground. The discharge should be piped at least 200 feet from the well, and downhill, if possible, to prevent recycling or "double counting." Do not run this dirty water through your plumbing.

If the drawdown in the well is at a relative maximum and has stabilized, this can be considered as the maximum safe yield of the well for that season of the year. This test should be run in the early fall when the groundwater table is generally at its lowest. Otherwise, it must be recognized that a lower water table will reduce the well's yield. The use of a very high capacity pump or fire truck to pump the well dry once then allowing it to refill, does not, in our opinion, provide useful information. For additional information concerning pump tests to determine well yield see fact sheet WD-DWGB-1-13 Determining the Yield of a Residential Well.

Disinfection - Chlorination
For new dug wells, or where well pumps have been recently replaced, it is most important to clean the well before chlorinating or testing for bacteria. The well may have to be continuously pumped for days (or weeks, in a few new well cases) before this cleaning process is complete. Chlorine, regardless of its concentration is NOT able to reach bacteria trapped inside

accumulations of mud. We strongly advise that a bacterial test NOT be taken until the well has been thoroughly flushed.

The well can be disinfected by adding chlorine. One gallon of 5.25 percent sodium hypochlorite (common store bleach, such as Clorox) in 1,000 gallons of water will provide a good disinfecting solution of 50 parts per million (ppm). The quantity of water inside the casing of dug wells is shown below:

Volume in Wells (Gallons)

Diameter **Water Depth**	**1'**	**2'**	**3'**	**4'**
2.5'	15	60	130	230
5.0'	30	120	260	460
10.0'	60	240	520	930
20.0'	120	470	1060	1880

The volume inside the well casing does not include the volume of water readily available in the crushed stone that normally surrounds the bottom of the well. As a rough rule of thumb, we suggest doubling the calculated volume.

The procedure outlined below should be followed when you disinfect your well. Add the chlorine directly to the well, plus an extra amount for the water in the crushed stone beyond the casing. Mix by using a strong flow of water through a clean garden hose recirculated directly back into the well. Run each faucet in your home until a chlorine smell is detectable. Close the faucets and allow the chlorine to stay in the well and the plumbing 12-24 hours.

Chlorine will not work its way uphill against the general movement of the watertable downhill. If your well's construction is "perfect," and if you still have bacterial problems, try digging one or two small holes into the soil "upstream" of the well and add a dilute chlorine solution directly into the ground. Refill these holes with fine grain soil. Then, flush that area with water from a hose to disperse the chlorine down to the watertable on the uphill side of the well. After 12-24 hours, flush chlorine from the water system. Flush onto the ground, but not into a stream or pond. For more information on disinfection please see fact sheet WD-DWGB-4-11 Disinfection a Private Well.

Testing New Wells for Water Quality

After ALL the chlorine is flushed from the well and plumbing system, a sample can be taken for bacterial and chemical testing. Remember all chlorine must be flushed from the well. Water quality samples with any chlorine can NOT be tested for bacteria and nitrate/nitrite. The presence of chlorine can be checked by using a chlorine test kit. Test kits are available from swimming pool suppliers or can be borrowed from neighbors with large swimming pools.

The DES laboratory conducts bacterial tests and a standard analysis, which tests for 13 water quality factors. Only DES sampling containers can be used. The time to process the standard analysis is approximately three weeks in the summer and two weeks otherwise. Different containers are required for sampling radon gas, industrial solvents and hydrogen sulfide.

Sampling containers can be obtained from the DES Laboratory Services Unit. See fact sheet WD-DWGB-2-1for Suggested Water Quality Testing for Private Wells. We recommend that a

bacterial sample be taken on an annual basis for dug wells in view of their shallow construction and non precise casing materials. Bacterial sampling is best done after heavy rainfall.

Please contact the Laboratory Services Unit at (603) 271-3445 or (603) 271-3446, or www.des.nh.gov/lab, for more information and/or for current fees.

Inspecting Existing Dug Wells

Rainfall washing across the surface of the ground picks up bacteria and virus. Bacteria and virus are removed from water percolates down through the soil layers. The presence of bacteria in a water sample implies that the filtration step has been subverted or that the well's configuration has one or more defects.

When inspecting an existing dug well, look for any defects or openings in the casing that will allow foreign substances or small animals to enter the well. Also look for points where surface runoff can enter the well casing directly. The essence of good construction is ensuring filtration of all water that enters the well.

Existing dug wells, especially those built of field-stone, are frequently subject to construction deficiencies which allow surface runoff, carrying bacteria and virus, to enter the well unimpeded. To prevent this problem, all joints between the field stones, near the top part of the well, should be mortared, and then the entire outside surface of the well, to a few feet below the finished backfill grade, should be uniformly coated with cement mortar so as to provide a smooth, one piece exterior surface. This sealing should extend down below the ground surface to the extent that conditions permit. Accomplishing this one piece construction requires a substantial effort for field stone wells.

Typically in older wells, the backfill around the well casing has settled. Where concrete or V.C. tiles have been used, the top two joints should be sealed if possible. Once completed, soil should be mounded up around outside of the well as shown.

Wood covers are another common dug well deficiency because they allow leakage and are susceptible to rotting. Further, water and debris can drain between the wood slats and into the well unfiltered. We recommend a solid one-piece concrete cover. The cover should extend beyond the well casing. The backfill next to the well casing should be mounded.

To achieve reliable bacterial water quality, the well construction MUST exclude ALL dust, dirt, surface water, and animals. If the well is not tight, and if there is not effective filtration of every drop of water entering the well, the well is NOT safe to use.

For Additional Information

Please contact the Drinking Water and Groundwater Bureau and the New Hampshire Water Well Board at (603) 271-2513 or dwgbinfo@des.state.nh.us or visit our website at www.des.nh.gov/dwgb. All of the bureau's fact sheets are on-line at www.des.nh.gov/dwg.htm.

Note: This fact sheet is accurate as of January 2007. Statutory or regulatory changes, or the availability of additional information after this date may render this information inaccurate or incomplete.